Integrated Multi-Objective Optimization of Supply Chain Under Customer Oriented Dynamic Environment

A
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INTRODUCTION

1.1 GENERAL INTRODUCTION

In present business environment, an efficient and effective supply chain is necessary for staying competitive in the market. A *supply chain* is a network of activities that span enterprise functions of procurement of materials, transformation of these materials into intermediate and finished products, and the distribution of these finished products to customers. Supply chains exist in both service and manufacturing organizations, although the complexity of the chain varies greatly from industry to industry and firm to firm. The supply chain is a dynamic supply and demand network that involves the constant flow of information, product, and funds between different stages. Various stages of supply chain are as follows (Figure 1):

- Component/Raw material suppliers
- Manufacturers/ Factories
- Warehouses/Distribution Centers
- Customers

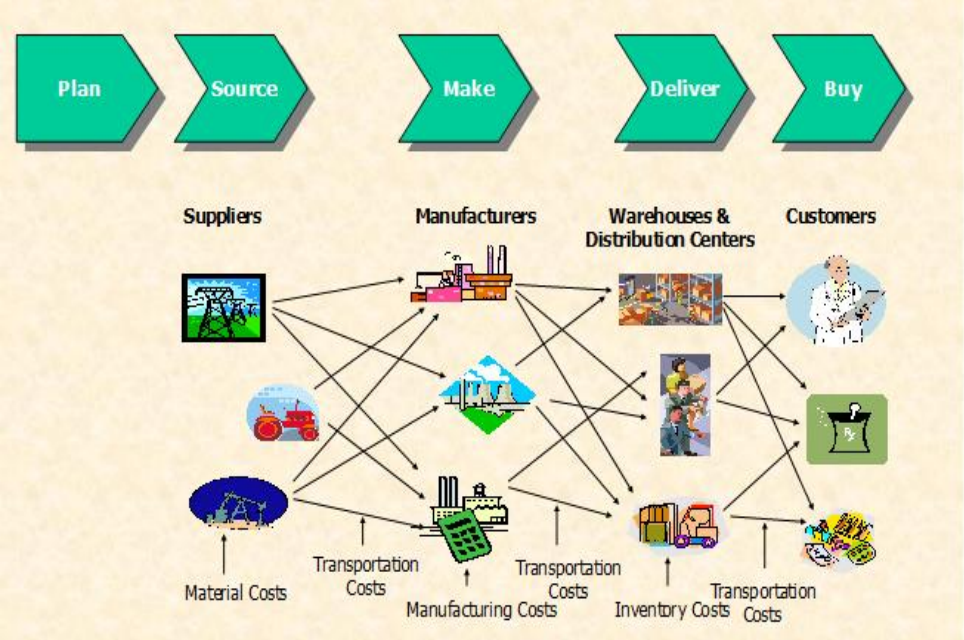

Figure 1: Stages of a supply Chain (*Source*: http://www.stevens.edu.ppt)

Supply chain activities include product development, sourcing, production, and logistics, as well as the information systems to coordinate these activities. While supply chains have existed for a long time, most organizations have only paid attention to what was happening within their *four walls*. Few businesses understood, much less managed, the entire chain of activities that ultimately

delivered products to the final customer. The result was disjointed and often ineffective supply chains.

Supply Chain Management is a set of synchronised activities (Figure 2) for integrating suppliers, manufacturers, distributors and customers efficiently so that the right product or service is delivered at the right quantities, at the right time, to the right places. The ultimate objective of Supply Chain Management is to maximize customer value and achieve sustainable competitive advantage. Geographical Information System can be an effective SCM tool to map manufacturing clients, processing units, supplier locations, distribution centers and routing of vehicles.

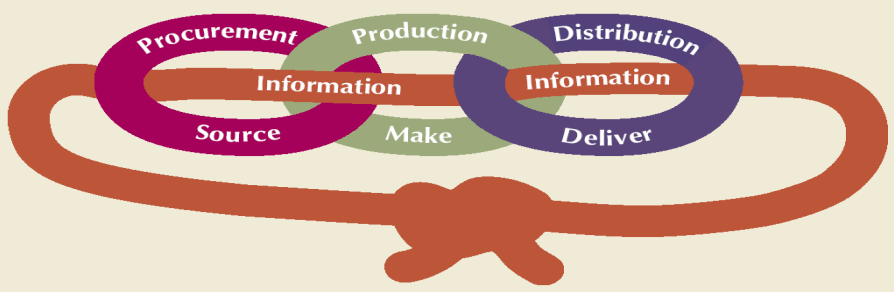

Figure 2: Supply Chain Management (*Source*: http://is.ba.ttu.edu.ppt)

The field of supply chain management has more recently directed its attention to the role of the supply chain in both (a) impacts to the natural environment and (b) the generation of environmental performance change. This shift has arisen from growing social pressure, legislative changes around packaging and end-of-life goods, identified supply chain risks, and increasing use of environmental requirements being cascaded from customers to suppliers.

Green Supply Chain Management integrates ecological factors with Supply Chain Management principles to address how an organization's supply chain processes impact the environment. Organizations are increasingly becoming aware of the impact of tight integration of supply chain and environmental management systems in enabling a sustainable business strategy. Many are now seeking out solutions and guidance on how to implement a sustainable supply chain. A sustainable supply chain is a supply chain that is not only optimal for the organization, but is optimal relative to its limited environmental impact.

The global competition, margin pressures and demand uncertainties have driven firms to focus more on supply chain optimization than firm level optimization. Supply Chain Optimization brings a system approach to understand and manage different activities needed for coordinating the flow of

products to services to best serve the ultimate customer. It is important for firms to understand the dynamic relations among various factors and provide guidelines for management to minimize the impact of demand uncertainty on the performance of the supply chain. Various aspects of supply chain optimization include liaising with suppliers to eliminate bottlenecks; sourcing strategically to strike a balance between lowest material cost and transportation, implementing techniques to optimize manufacturing flow; vehicle routing analysis etc. which require complex decision making procedure. Decision Support System (DSS) has emerged as a powerful tool for supply chain optimization to provide analysis and comprehension of complex supply chain effectively.

1.2 DECISION SUPPORT SYSTEM

In a world of constant flux, informed and thoughtful decision-making is the cornerstone of supply chain success. Decision Support Systems allow faster decision making, identification of negative trends, and better allocation of supply chain resources to the benefit of supply chain stakeholders and their organizations. Decision Support Systems are a specific class of computerized information system that also supports supply chain optimization decision-making activities.

Decision Support Systems analyze business data and provide interactive information support to supply chain stakeholders during the decision-making process, from problem recognition to implementing the decision. Decision Support Systems use (1) analytical models, (2) specialized databases, (3) a decision maker's own insights and judgments, and (4) an interactive modeling process to support semi-structured business decisions. The role of model-based decision making is gaining increasing importance as organizations try to achieve a competitive edge.

Decision Support Systems provide following benefits to the supply chain stakeholders:

- Speeding up the process of decision making
- Increasing organizational control
- Speeding up the problem solving in an organization
- Helping automate managerial processes
- Improving personal efficiency
- Eliminating value chain activities

Decision Support System has been integrated into many multi-criteria decision making activities and business processes of the supply chain like logistics management, inventory management, sales and distribution planning, materials and production planning.

1.3 MULTI CRITERIA DECISION MAKING

Multi criteria decision making is an important part of modern decision science, aimed at supporting decision makers faced with multiple decision criteria and multiple decision alternatives. The development of Multi criteria decision making methods has been motivated not only by a variety of real-life problems requiring the consideration of multiple criteria, but also by practitioners' desire to propose enhanced decision making techniques using recent advancements in mathematical optimization. In recent decades, several mathematical methods have been developed for selecting the most preferable alternatives supporting Decision Makers faced with numerous and sometimes conflicting objectives. These methodologies can be categorized in a variety of ways, such as linear, non-linear methodologies and so on.

Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) is an emerging solution approach to large, dynamic and complex real world multi criteria decision making problems. It is a comprehensive, logical and structured framework that allows improving understanding of complex decisions by decomposing the problem. The method has the ability to structure complex, multi-person, multi-attribute and multi-period problem hierarchically. It is very useful in the situations involving several decision makers with different conflicting objectives to arrive at a consensus decision. The benefits of AHP are:

- It initiates the way human think about the decision making
- It simplifies the structure of a decision process
- Both quantitative and qualitative attributes/criteria can be used
- Consistency in the judgment can be checked
- Pairwise comparison allows the decision maker to determine the trade-offs among criteria

Goal programming

The multi criteria decision making and goal based philosophy has been formalized in the modern field of operational research and management by the technique of Goal Programming (GP). A formal theory of Goal Programming, a well-known modification and extension of linear programming, was given by **Charnes and Cooper [18]**. The Authors suggested that each constraint in an LP model is viewed as individual objective or goal to be attained. In effect there are a set of goals that one must satisfy to have a feasible solution. Therefore, the goal attainment is achieved by minimizing their absolute deviation. In LP problems, having infeasible solutions where deviation in goals is inevitable, the best solution occurs by minimizing the deviation $\left| \sum_{j=1}^{n} a_{ij} x_j - b_i \right|$.

Recognizing that deviations from goals will exist in unsolvable Linear Programming problems, **Charnes and Cooper [18]** demonstrated that the deviation could be minimized by placing the variables representing deviation directly in the objective function of the model. This allows multiple (sometimes conflicting) goals to be expressed in a model that will permit a solution to be found. Hence, Goal programming can be used as an effective approach to handle a decision concerning multiple and conflicting goals.

A general GP model can be expressed as,

$$\text{Minimize } Z = \sum_{i \in m} d_i^+ + d_i^-$$

$$\text{s.t. } \sum_{j=1}^{n} a_{ij}x_j - d_i^+ + d_i^- = b_i, \text{ for } i = 1,2,\ldots\ldots,m$$

$$d_i^+, d_i^- \text{ and } x_j \geq 0, i = 1,2,\ldots\ldots,m\ ;\ j = 1,2,\ldots\ldots,n$$

where d_i^+ and d_i^- are called positive and negative deviational variables, b_i represents the objective target or goal of the i^{th} resource. In the above model i is an element of the m possible positive and negative deviation variables which implies that choice in the selection of deviation variables to be included in the objective function is an option. The above GP model has an objective function, constraints (called goal constraints) and the same non-negativity restrictions on the decision and deviational variables as the LP model.

The three major variants of Goal Programming in terms of distance metric are:

- Lexicographic or Pre-emptive Goal Programming
- Weighted or Minisum Goal programming
- Chebyshev or Minmax Goal Programming

Lexicographic or Pre-emptive Goal Programming

The lexicographic minimization of the objective function means that the minimization of deviational variables placed in a higher priority level is regarded as infinitely more important than that of deviational variables placed in a lower priority level. This results in a series of sequential optimizations, each of which has a reduced feasible region as the minimal values of the higher priority level optimizations must be maintained. The model can be stated as,

$$\text{Minimize } Z = \sum_{i \in m} P_i\ d_i^+ + d_i^-$$

$$\text{s.t. } \sum_{j=1}^{n} a_{ij}x_j - d_i^+ + d_i^- = b_i, \text{ for } i = 1,2,\ldots\ldots,m$$

$$d_i^+, d_i^- \ \&\ x_j \geq 0, i = 1,2,\ldots\ldots,m\ ;\ j = 1,2,\ldots\ldots,n$$

Here, P_i are the pre-emptive priority factors who serve only as a ranking symbol.

The distinguishing feature of lexicographic approach is that, it defines different priority levels P_i for the goals of the analysis. The different priority levels reflect the hierarchical relationship between the targets in the objective function where they are arranged in order of decreasing priority ($P_1 > P_1 > \ldots > P_m$).

Weighted or Minisum Goal Programming

This model is non-preemptive that seeks to minimize the total weighted deviation from all goals stated in the model. The weighted goal program allows for direct trade-offs between all unwanted deviational variables by placing them in a weighted single objective function.

The Weighted Goal Programming Model can be defined as,

$$\text{Minimize } Z = \sum_{i \in m} w_i^+ d_i^+ + w_i^- d_i^-$$

$$\text{s.t. } \sum_{j=1}^{n} a_{ij} x_j - d_i^+ + d_i^- = b_i, \text{ for } i = 1,2, \ldots \ldots, m$$

$$d_i^+, d_i^- \ \& \ x_j \geq 0, i = 1,2, \ldots \ldots, m \ ; \ j = 1,2, \ldots \ldots, n$$

where, w_i^+ and w_i^- are non negative constants representing the relative weight to be assigned to the respective positive and negative deviational variables. The relative weights may be any real number, where, the greater the weight the greater is the assigned importance to minimize the respective deviation variable to which the relative weight is attached.

Chebyshev or Minmax Goal Programming

The third major variant of Goal programming was introduced by **Flavell [31]** known as Chebyshev Goal Programming, because it uses the underlying Chebyshev (L_∞) means of measuring distance. That is, the maximal deviation from any goal, as opposed to the sum of all deviations is minimized. For this reason, it is also sometimes termed as Minmax Goal Programming. The idea behind using the L_∞ distance metric is that of balance i.e. the decision maker is trying to achieve a good balance between the achievement of set of goals. If λ be the maximal deviation from amongst the set of goals, then the Chebyshev Goal Programming has the following algebraic format,

$$\text{Minimize } Z = \lambda$$

$$\text{s.t. } \sum_{j=1}^{n} a_{ij} x_j - d_i^+ + d_i^- = b_i, \text{ for } i = 1,2, \ldots \ldots, m$$

$$w_i^+ d_i^+ + w_i^- d_i^- \leq \lambda \text{ , for } i = 1,2, \ldots \ldots, m$$

$$d_i^+, d_i^- \ \& \ x_j \geq 0, i = 1,2, \ldots \ldots, m \ ; \ j = 1,2, \ldots \ldots, n$$

The variants of Goal Programming in terms of the mathematical nature of the decision variables and/or goals used are fuzzy, integer, binary, and fractional goal programming.

LITERATURE SURVEY

2.1 INTRODUCTION

Increasing competition in global markets, shortened product life cycles and heightened customer expectations have forced researchers to focus on the supply chains. **Seliaman and Ahmad [75]** developed a model to deal with different inventory coordination mechanisms between the supply chain members viz. suppliers, manufactures, and retailers, under stochastic demands, so that the total cost of the system is minimized. **Bidhandi and Yusuff [10]** proposed an integrated model and a modified solution method for solving supply chain network design problems under uncertainty. **Helper et al [35]** conducted a numerical study to quantify the benefits of information sharing to the retailers under varying levels of supplier capacity and supply allocation mechanisms. **Zegordi et al [91]** considered the scheduling of products and vehicles in a two-stage supply chain environment. The situation was modeled as a mixed integer programming problem and a gendered genetic algorithm. **Choi et el [24]** carried out a mean–variance analysis of supply chains under a returns policy and proposed an MV formulation for a single supplier single retailer supply chain with a newsvendor type of product.

Esmaeili et al [30] proposed several seller–buyer supply chain models which incorporated both cost factors as well as elements of competition and cooperation between seller and buyer. The relationships between seller and buyer were modeled by non-cooperative and cooperative games, respectively. **Cheng and Ye [22]** introduced an evaluation criterion of production load equilibrium among parallel suppliers for an order splitting problem. A two objective order splitting model was developed to minimize the comprehensive cost and balance the production loads among the selected suppliers. **Rezaei and Ortt [70]** discussed the various factors to be considered while segmenting suppliers and proposed a new approach to supplier segmentation. **Hvolby et al [37]** focused on supply chain relationships and segmented planning. A framework, with dimensions customization and integration, linking supplier typologies with supply chain planning solutions was presented.

Jain et al [39], [40] discussed issues related to modeling a dynamic supply chain. **Sadeghieh et al [72], Rojas and Frein [71]**, **Kazemi et al [43], Li et al [51], Akyuz and Rehan [2]** and **Orcun et al [59]** developed different algorithms and models to improve supply chain visibility, and quantify and exploit holistic supply chain performance. **Cheung et al [23]** presented a knowledge-based Customization system (KBCS) for supply chain integration and verified its use for improving supply chain visibility. **Kristianto et al [46]** developed system dynamic based computer simulation model to

validate the operations of the supply chain with an objective to improve the level of integration in all aspects of supply chain reconfiguration by incorporating manufacturing and product design into logistic design. **Kumar et al [47]** considered a multi-echelon global supply chain model, where raw material suppliers, manufacturers, warehouses and markets are located in different countries and applied various computational intelligence techniques in the solution evaluation phase. **Mason and Lalwani [57]** charted a range of diagnostic tools for better transport integration and demonstrated that these can be utilized by transport and supply chain managers to assess what is happening within their supply chains, how well they are performing and the degree of integration, especially of the transport function with related supply chain echelons. **Silva et al [79]** introduced a new supply chain management (SCM) technique, ant colony optimization, which allows the exchange of information between different optimization problems by means of a pheromone matrix. **Tsai [84]** solved a nonlinear SCM model capable of treating various quantity discount functions simultaneously, including linear, single breakpoint, step, and multiple breakpoint functions. **Shukla et al [78]** proposed a hybrid approach incorporating simulation for SCM, Taguchi method, robust multiple non-linear regression analysis and the Psychoclonal algorithm to identify the optimal operating condition incurring minimum total costs under the complexities involved in the dynamic interaction among multiple facilities and locations. **Rexhausen et al [69]** extended the stream of research in supply chain management by systematically investigating the impact of customer-facing supply chain practices on supply chain performance and examined the relative impact of relevant practices associated with demand and distribution management. **Wu et al [88]** proposed a novel joint learning scheme for service site selection by employing both the Probabilistic Latent Semantic Analysis (PLSA) on the Geographical Information System (GIS) data and the partitional clustering on the service performance data. **Berman and Krass [9], Cheng and Chang [20], Cheng et al [21]** applied Geographical Information System approach for Supply Chain Management and route planning. **Liu et al [55]** proposed a new hub-and-spoke integration model to integrate green marketing and sustainable supply chain management from six dimensions: product, promotion, planning, process, people and project (called the 6Ps).

Green marketing and green supply chain have been drawing the attention of both academics and practitioners in the recent decade. **Olugu et al [58], Andiç et al. [4], Sheu [77]** and **Zhu et al [94]** developed a set of measures for evaluating the performance of the green supply chain. **Bose and Pal [12]** determined what causes statistically significant gain in stock prices for Manufacturing firms and concluded firms with high R&D expenses, and early adopters show a strong increase in stock prices on the day of the announcement. **Diabat and Govindan [27]** developed a model of the drivers affecting the implementation of green supply chain management using an Interpretive Structural

Modeling (ISM) framework. **Pishvaee and Razmi [66]** proposed a multi-objective fuzzy mathematical programming model for designing an environment supply chain. **Azevedo et al. [8]** investigated the relationships between green practices of supply chain management and supply chain performance. This relationship was investigated in the context of the automotive industry. **Abdallah et al [1]** developed a mixed integer program for the carbon-sensitive supply chain that minimizes emissions throughout the supply chain by taking into consideration green procurement also known as environmental sourcing. **Chan et al [17]** reflected the most recent advances on green industrial marketing, green/sustainable supply chains and their interplay in green industrial branding, to explore future research directions. **Ivanov et al [38]** developed an integrated model of production and transportation planning in the supply chain based on a combination of fundamental results of the modern optimal program control (OPC) theory with the optimization methods of OR. The optimization of green suppliers is a key step in green supply chain management. **Peng [65]** developed a vendor evaluation system based on green supply chain management by integrating AHP and Grey Relational Analysis to solve the problem of green supplier evaluation. **Paksoy et al [64]** developed an optimization model of a closed-loop supply chain network which starts with the suppliers and recycles with the decomposition centers. To pay attention for the green impacts, different transportation choices were presented between echelons according to their CO_2 emissions.

Altiparmak et al [3] proposed a solution procedure based on genetic algorithm to find the set of Pareto-optimal solutions for multi-objective Supply Chain Network design problem. To deal with multi-objective and enable the decision maker for evaluating a greater number of alternative solutions, two different weight approaches were implemented in the proposed solution procedure. **Ghirardi et al [32]** presented a suitable model of distributed supply-chains (DSCs) with the aim of providing a tool for DSC decentralized optimization. **Kanyalkar and Adil [42]** considered the planning problem in the context of a multi-site procurement-production-distribution system motivated from a real life case of a multinational consumer goods company. A robust optimization model was developed for integrated planning. **Zhang et al [92]** presented a new manufacturing resource allocation method using extended genetic algorithm to support the multi-objective decision-making optimization for supply chain deployment. **Eremeev et al [29]** proposed a fully polynomial time approximation scheme for optimizing the product delivery from suppliers to consumers when the size of each open supply is bounded both below and above. **Gjerdrum et al [33]** described and evaluated approaches for finding optimal parameters for supply chain systems. **Li and Womer [50]** developed a hybrid Benders decomposition (HBD) algorithm combining the strengths of both mathematical programming and constraint programming to solve the multi-mode resource-constrained project scheduling problem with a nonlinear objective function. The model

simultaneously optimized sourcing and supply chain planning decisions while exploiting their tradeoffs. **Xu and Nozick [90]** formulated a two-stage stochastic program and a solution procedure to optimize supplier selection to hedge against the loss of production capability at supplier sites. **Tiwari et al [82]** proposed a Highly Optimized Tolerance (HOT) algorithm for solving a multi-stage, multi-product supply chain network design problem. The objective was to reduce the total cost of supply chain distribution by selecting the optimum number of facilities in the network. **Crnkovic et al [26]** presented a simulation-based decision-support framework for exploring the tradeoffs in producing different quantities under a variety of supply chain configurations and alternate forecasting options, given uncertain demand environments.

2.2 DECISION SUPPORT SYSTEM

Decision-making is an important stage of management activity defining, to a large extent, efficiency of the latter. A properly designed Decision Support System (DSS) is an interactive software-based system intended to help decision makers in compiling useful information from raw data, documents, personal knowledge, and/or business models to identify and solve problems and make decisions. **Mansouri et al [56]** identified the gaps in decision-making support based on multi objective optimization (MOO) for build-to-order supply chain management (BTO-SCM). **Dutta et al [28]** described how a generic multi-period optimization-based Decision Support System can be used for strategic planning in process industries. The system was user friendly and required little knowledge of optimization. **Chou and Chang [25]** presented a strategy-aligned fuzzy SMART based DSS for solving the supplier/vendor selection problem from the perspective of strategic management of the supply chain. **Suzuki [80]** proposed a DSS that allowed motor carriers to route each vehicle such that the vehicle not only visits all the customers in time (without violating time windows), but also utilizes the cheapest gas stations (cheapest truck stops in the region) as refueling points during the tour. **Repoussis et al [68]** presented a web-based DSS that enabled schedulers to tackle reverse supply chain management problems interactively. The focus was on the efficient and effective management of waste lube oils collection and recycling operations. Focusing on the operational level of SCM, a framework for DSS was proposed by **Bonfill et al [11]** to address the interrelated production and transport scheduling problems from the perspective of a production plant of a multi-site system that owns, or leases on a long-term basis, a fleet of vehicles to distribute the products. **Schellenberg et al [73]** presented a DSS to minimize the time it takes to generate a factory plan while providing better accuracy and visibility of the material flow within the supply chain. **Aslam and Amos [5]** presented a DSS framework by applying ABS and simulation-based optimization techniques to supply chain management, which considers the entities (supplier, manufacturer, distributor and retailer) in the supply chain as intelligent agents in a simulation. **Ortuño et al [60]** presented a lexicographical goal

programming model for distribution of goods to the affected population of a disaster in a developing country, which sustains a decision support system currently in development. **Cakir and Canbolat [15]** proposed an inventory classification system based on the fuzzy analytic hierarchy process (AHP), a commonly used tool for multi-criteria decision making problems and integrated fuzzy concepts with real inventory data and designed a decision support system assisting a sensible multi-criteria inventory classification.

2.3 MULTI-CRITERIA DECISION MAKING

Integration of multi-criteria decision making (MCDM) with DSS brings benefit to both fields. Over the years, MCDM has made considerable contribution to the development of various decision making subspecialties. **Azaron et al [7]** presented a multi-objective stochastic programming approach and developed a robust model for supply chain design under uncertainty. Demands, supplies, processing, transportation, shortage and capacity expansion costs were all considered as the uncertain parameters. **Kuo et al [48]** applied various multi-criteria decision making methodology for green supplier selection. **Li et al [52]** presented Axiomatic Fuzzy Set clustering method, which handles ambiguity and fuzziness in the supplier selection problem effectively. To address multiple decision criteria in supplier ranking, the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is employed to select the final suppliers. **Thanh et al [81]** developed a dynamic model for facility location in complex supply chains. **Chen et al [19]** presented a supply chain planning model as a multi-objective mixed-integer linear program to satisfy several conflict objectives, such as minimizing the total cost, raising the decision robustness in various product demand scenarios, lifting the local incentives, and reducing the total transport time. **Wu et al [89]** proposed a two-stage approach, based on the application of an analytic network process-mixed integer multi-objective programming model, to solve the problem of partner selection in agile supply chains (ASCs). **Shaw et al [76]** presented an integrated approach for selecting the appropriate supplier in the supply chain, addressing the carbon emission issue, using fuzzy-AHP and fuzzy multi-objective linear programming.

Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) technique intends to facilitate the MCDM problems that have a hierarchical structure of attributes. **Zhang et al [93]** developed a hybrid methodology combining the data envelopment analytic hierarchy process (DEAHP) and activity-based costing for supplier evaluation and made decisions on supplier selection and order quantity within an integrated single objective function which is based on consideration of the budget of the buyer and of the capacity of the supplier. **Wang et al [87]** proposed AHP for the formulation of factor weights and developed an improved particle swarm optimization algorithm for solving the mathematical model. **Korpela et al [45]** proposed an approach for selecting the warehouse operator network by combining the AHP and the data envelopment analysis. **Özgen et al [62]** integrated the AHP and a multi-objective possibilistic linear programming technique to account for all tangible, intangible, quantitative, and qualitative factors which were used to evaluate and select suppliers and to define the optimum order quantities. **Schoenherr et al [74]** reported the process used by a US manufacturing company to assess supply chain risks within the context of an offshore sourcing decision and discussed the research streams of offshoring and risk management in purchasing and supply, as well as to decision-making under uncertainty and AHP.

Büyüközkan [13] applied fuzzy AHP to determine the relative weights of the evaluation criteria and an axiomatic design-based fuzzy group decision-making approach to rank the green suppliers. **Awasthi and Chauhan [6]** presented a hybrid approach based on Affinity Diagram, AHP and fuzzy TOPSIS for evaluating city logistics initiatives. The approach can be practically applied for selecting sustainable city logistics initiatives for cities. **Chan and Kumar [16]** discussed Fuzzy extended analytic hierarchy process (FEAHP) based methodology to tackle the different decision criteria like cost, quality, service performance and supplier's profile including the risk factors involved in the selection of global supplier in the current business scenario. **Kilincci and Onal [44]** developed fuzzy AHP based methodology to select the best supplier firm providing the most customer satisfaction for a well-known washing machine company in Turkey. **Büyüközkan and Berkol [14]** presented a decision framework where analytic network process integrated quality function deployment and zero-one goal programming models were used in order to determine the design requirements which are more effective in achieving a sustainable supply chain.

Goal Programming

Since the development of goal programming in 1961 **[18]**, there has been substantial research into applying goal programming to various MCDM problems. **Tsai and Hung [85]** proposed a fuzzy goal programming approach that integrated activity-based costing and performance evaluation in a value-chain structure for optimal green supply chain (GSC) supplier selection and flow allocation. **Liang [53]** developed a two-phase fuzzy goal programming method for solving the project management decision problems with multiple and conflicting goals in uncertain environments. **Jamalnia and Soukhakian [41]** developed a hybrid (including qualitative and quantitative objectives) fuzzy multi objective nonlinear programming (H-FMONLP) model with different goal priorities for aggregate production planning problem in a fuzzy environment. **Liao and Kao [54]** proposed integrated fuzzy techniques for order preference by similarity to ideal solution and multi-choice goal programming approach to solve the supplier selection problem. **Torabi and Hassini [83]** proposed a fuzzy approach to convert the Fuzzy Goal Programming model into an auxiliary crisp formulation to find an efficient compromise solution. **Golany et al [34]** proposed an interactive Goal Programming for operational recovery problems that are present in diverse areas of application and discussed its relevance to scenarios taken from airline scheduling and call centers operations. **Ravindran et al [67]** developed multi criteria supplier selection models incorporating supplier risk and applied them to a real company. The multi-objective optimization problem was solved using four different variants of goal programming. **Paksoy and Chang [63]** developed a multi-period and multi-stage with multi-choice goals under inventory management constraints and solved by 0–1 mixed integer linear programming. **Osman and Demirli [61]** discussed a problem related to an aerospace company seeking to change its outsourcing strategies in order to meet the expected demand increase and customer satisfaction requirements regarding delivery dates and amounts. A bilinear goal programming model was developed to achieve the company's objectives. **Leung and Chan [49]** developed a pre-emptive goal programming model to maximize profit, minimize repairing cost and maximize machine utilization of the Chinese production plant hierarchically. **Ustun [86]** proposed a multi-choice goal programming formulation based on the conic scalarizing function with three contributions: (1) the formulation allows the decision maker to set multi-choice aspiration levels for each goal to obtain an efficient solution in the global region, (2) the proposed formulation reduces auxiliary constraints and additional variables, and (3) the proposed model guarantees to obtain a properly efficient (in the sense of Benson) point. **Hung [36]** proposed to combine activity-based costing with economic incentive schemes (EISs). A zero-one goal programming model was discussed to decide the optimal qualities after the activity cost analyses, which were then utilized to determine the optimal incentive amounts by the Economic Incentive Schemes.

PROPOSED RESEARCH WORK

Dealing competitiveness and continue to subsist in today's dynamic marketplace due to rapid globalization is very demanding and needs an appropriate business strategy. Also managing competition and establishing an efficient supply chain network under conflict objectives, supply-demand uncertainty and higher customer service level is a challenging and complex task. With such level of complexity in the environment, supply chain optimization has a potential to make a significant contribution to resolve the challenges.

The proposed research study will be devoted to model **Integrated Multi-Objective Optimization of Supply Chain under Customer Oriented Dynamic Environment**. There are a lot of factors to evaluate the performance of the supply chain such as customer service, quality, lead time, cost and so forth. But due to the environmental requirements an increasing attention has to be given to develop environmental strategies.

The proposed research objectives are:

- Development of Multi-Objective Optimization Model to capture trade-off between the total cost and the environment influence.
- Design and development of Sustainable Supply Chain Architecture.
- Spatial Analysis for eradicating environmental risks at all echelons of the supply chain.
- Development of Decision Tools and Solution Approaches.

The framework of proposed Model and its benefits are as illustrated in Figure 3.

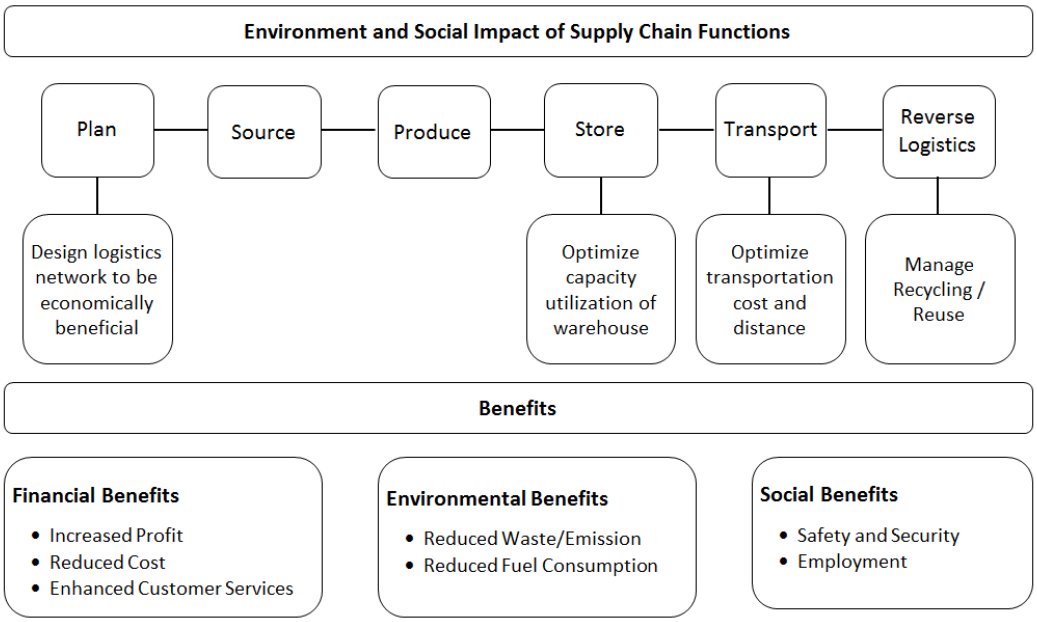

Figure 3: Framework of proposed Model

The developed Model will help in maximizing both the overall profit and the satisfaction of the customers. By using this model, systematic decisions related to supply chain echelons can be made and a rational set of results will be obtained. The proposed model will be able to adjust its strategy depending on changes in customer demand and will have the strong advantage of dynamism.

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